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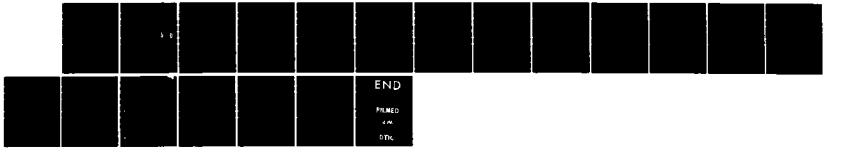

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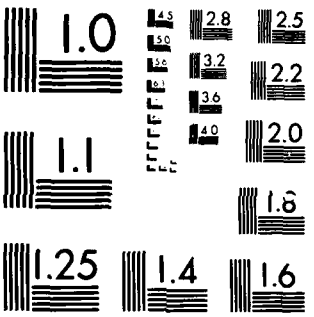

December 31, 1982

FINAL REPORT FINDINGS & RECOMMENDATIONS

FASCAM Soldering Process
Control Evaluation

Prepared For

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BATTELLE COLUMBUS LABORATORIES

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The views, opinions, and/or findings contained in this report are those of the author and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

EXECUTIVE SUMMARY

This report presents the findings and recommendations of Joseph Sylvester, Omni Training Corp, Covina, CA. During the course of working on this project, the writer observed the ADAM and RAAM production areas at the Honeywell facilities in New Brighton, Minnesota. Numerous organizational meetings were held at ARRADCOM, Dover, NJ.

This report includes complete, as submitted, the original and subsequent revised process control documents generated by personnel at Honeywell, New Brighton, Minnesota.

Recommendations made in this report are based on successful, time proven practices being used in industry today.

RECOMMENDATIONS

The following recommendations are presented in approximate order of priority:

1. All future ARRADCOM "Tech" packages should be written to have FASCAM products manufactured in conformity with existing specifications -- eliminate deviations.

2. Condition of contract award be an acceptable process control specification. Process control will ensure uniformity of high quality production.

3. Solderability testing and preservation is a prime requisite in effective process control. Solderable materials and well controlled soldering processes will eliminate the need for specification deviations.

4. Process control is dependent upon administration by trained personnel. Honeywell FASCAM soldering document, Section V "Soldering Certification Training" outlines their plan. This program should be monitored to evaluate its effectiveness.

5. Promote similarity of operations in the manufacturing effort of RAAM and ADAM FASCAM products. Processes, controls and manufacturing engineering philosophy and dedication should be similar to ensure uniformity of high reliability products.

6. Visits to the Honeywell facility disclosed that ADAM productivity and quality could be improved by possible changes in fixturing and processing.

   a. Automatic Insertion Machine

   b. Conveyor Fixtures/Pallets

      Wave Soldering Machine

7. All existing and future tech packages should be evaluated for proper solder joint design attributes:

   Lead to Hole
   Hole to Pad Concentricity
   Pad Size
   PWB Shape

8. RAAM wave soldering process now being operated using established process controls, and also reflecting improvements made by machine operator and the industrial engineer. This action should result in improved quality uniformity.

9. Present Honeywell FASCAM deviation/quality assurance provisions will be changed from line drawings to actual color print photography. This should aid in determining acceptable solder connections. Every effort must be made to have acceptance criteria satisfy the specification requirements.

10. Many inspection plans have been discussed. ARRADCOM has a quality control consultant working on this phase of process control. Until a mutually accepted plan has been selected and proven out, the inspection plans outlined on the specifications must be used.

11. Assemble and provide ARRADCOM engineering personnel with a soldering workmanship manual clearly showing the soldering quality acceptance levels established by the governing specifications.

12. Continue to conduct soldering technology seminars and workshops at ARRADCOM utilizing the training facilities of Mr. E. Miller to train ARRADCOM engineering personnel in the working of hand and wave soldering.

13. Visit to Aerojet, Downey, CA with Messers. Fitzsimmons and Schubert. Plant tour of FASCAM area--asked to evaluate wave soldering process. Assigned task of designing wave soldering fixture and to help Aerojet in FASCAM pre-production effort.

ELABORATION OF RECOMMENDATIONS

#1

The writer recommends that all future ARRADCOM "Tech" packages be written to have FASCAM products manufactured in conformity with contracted specifications. This will eliminate the need for quality deviations.

This is a time proven concept. In recent years there has been a growth of mandated quality planning, imposed on industry by major forces (such as the government) in the economy.

The government is faced with placing contracts for high volume products with many vendors. The technological aspects of these can be unique to each product. However, there is much commonality in quality planning so that standardization of quality planning is feasible. An effective plan is to train and control contractors and suppliers in quality disciplines to raise their level of sophistication with respect to quality.

Long life products have some quality characteristics (reliability, shelf-life) that are not verifiable by conventional inspection and testing methods. Much depends on product design, the process capability and the controls exercised at the contractor's plant. The government is buying not only the product, but also such services as product design, process specification and process control. The performance and life of these products

is heavily influenced by some critical decisions made by the contractor in the early stages of progression of the products.

For the purchase of modern products, wide use is made of design review (with associated design qualification testing) to ensure manufacturing capability. The government should perform a contractor survey with emphasis on process capability data. To aid in maintaining control during manufacturing, the contract may impose mandated quality planning on the contractor, and enforce this through periodic audits or contractor surveillance.

Process controls are the software of manufacturing planning. Their purpose is to enable the work force to set up, run and regulate the process so the result will be a quality product.

Steps should be taken to automate the manufacturing process to minimize human error as well as to improve productivity; foolproof the hand soldering operations to reduce or eliminate human error, and provide computer controls to minimize human error and to shorten the feedback loop.

Inspection criteria should be clearly defined. This would place ARRADCOM in a stronger contract position to select and work with the contractor best equipped to produce high reliability FASCAM products.

#2

One of the major objectives of our assigned task was to have a Process Control Specification written by Honeywell, Inc. that would be acceptable to ARRADCOM. Attached are all of the

These documents are not being included due to the fact that they are Competition Sensitive. This has been verified by Richard Schubert, ARRADCOM. (Submitted as required by contract. JEB)

submitted documents, from the original planning to the last document submitted. My comments and recommendations are hand written on each version. It is obvious that much time has been expended by all of the parties involved.

Process control is a way of life in successful manufacturing facilities involved in high reliability production and programs.

An effective process control program is one where any deviation from the norm is quickly fed back into the system and the operation adjusted to conform to the established control limits. Process control involves:

1. Inspection of the end product of an operation to determine its acceptability.
2. Documentation of all pertinent aspects of the operation including the end product inspection.
3. Feed back of the defect information into the operation.
4. Corrective action based upon the information fed back into the system from the end product inspection.

It is important to note that touch-up is not and should not be considered a part of process control.

A well specified process control specification, properly administrated, is the only way to ensure uniformity of high quality reliable production.

Line inspection will generate the on-going data bank to feed back into the process. Positive remedial steps must be taken immediately to correct any out of specification condition. This will build product confidence.

#3

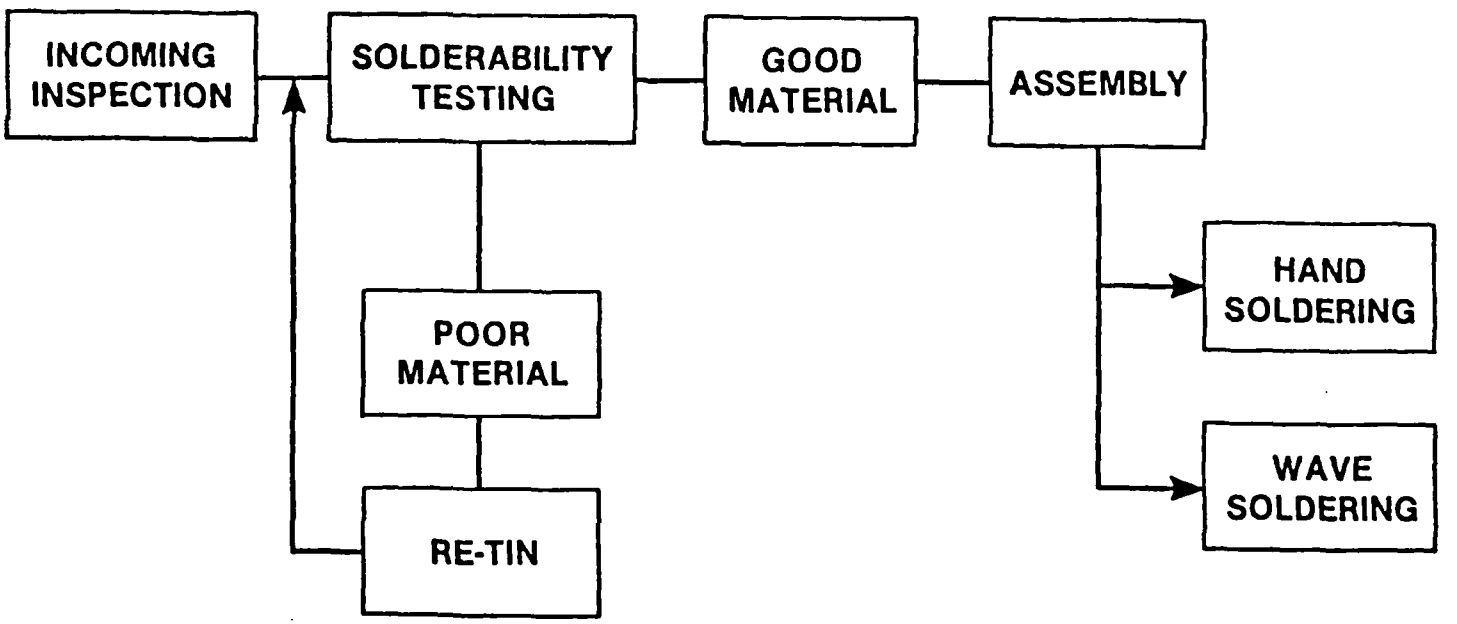
Solderability testing and preservation is a prime requisite in effective process control. Solderable materials and well conti .led soldering processes (hand and wave) will eliminate the need for specification deviations promoting conformity to contractual specifications.

Solderability Improvement:

Poor solderability of incoming components and printed wiring boards (PWBs) is a common problem in industry today. For this reason, many electronics companies have established facilities for component lead and PWB solderability improvement. The cost-effectiveness of retinning has been the subject of numerous seminars and papers. The consensus has been that providing solderable boards and components eliminates many of the observed soldering defects. This results in better solder joints with less time spent in touch-up and greatly minimizes the potentially harmful effects of solder joint reheating. The potential savings are well worth the initial cost outlay involved in setting up a facility for solderability improvement.

Figure 1 presents a simple block diagram outlining an effective solderability testing and improvement program. Incoming components and PWBs are tested for solderability. Material exhibiting good solderability is sent directly to assembly or storage. Components and boards failing the solderability test are first retinned and then retested to verify that they are now solderable. Any decision to accept components or boards that

FIGURE 1: **SOLDERABILITY IMPROVEMENT PROGRAM**



still do not exhibit good solderability after retinning should be made by a Material Review Board (MRB) which includes a representative from DCAS. It should also be noted that, per the specification, components and boards stored for longer than 120 days must be retested for solderability prior to use. This system allows only solderable material to be transported to the manufacturing areas. All movement of material, receiving, incoming inspection, solderability testing, acceptance or rejection, retinning and ultimate transfer to the production/storage area must be properly documented. These records should be made available for auditing by ARRADCOM and/or DCAS personnel.

The establishment of a solderability improvement program has allowed many companies to achieve higher productivity and improved soldering quality at lower costs. There is every reason to believe that the RAAM and ADAM lines can experience the same success.

This Solderability Improvement section was taken directly from the FASCAM Soldering Committee Report, February 24, 1982.

#4

Process control is dependent upon administration by trained personnel. Honeywell FASCAM Soldering Document Issue #4, October 26, 1982, Section V "FASCAM Training" outlines their plan. ARRADCOM must audit and/or monitor the program to assess its effectiveness.

#5

During our visits to the Honeywell, Inc., New Brighton facility, it was apparent that there was dissimilarity in the operations, manufacturing philosophy and manufacturing effort involved in producing RAAM and ADAM FASCAM products. Although some of the materials and technological aspects of these products can be unique to each product, there is commonality of quality planning so that standardization of quality planning and process control is possible.

During our visit to the RAAM production facility, it was gratifying to us (Schubert and Sylvester) to see the effects of the process control effort by Messers. Katavala and Babatz. With this attitude and dedication, the whole concept of process control is possible. The government will then be purchasing products with minimal or no touch-up which is the ultimate safeguard in marginal degradation of solder connections and components resulting from heat problems generated by hand soldering.

#6

During our meetings with Honeywell at the New Brighton facility, we discussed fixturing and processing of the ADAM unit.

First, recognizing the success of the RAAM wave soldering process which is being done using a palletless finger type conveyor, why shouldn't the same type of processing be used on the ADAM line?

I believe ARRADCOM should organize an investigative task

force to analyze the necessary required changes to the:

a. Artwork for printed wiring boards.

b. Automatic insertion equipment

c. Elimination of fixtures/pallets; use finger type conveyor.

#7

During our visits to Honeywell, Inc., and now Aerojet, Downey, CA, many of the engineers discussed the fact that improvements could be made in product design to improve component insertion and soldering.

It is important that all future ARRADCOM "Tech" data packages address the areas of:

a. Lead to hole dimensions

b. Hole to pad dimensions

c. Pad size

d. Hole to pad concentricity

e. PWB shape

Proper specification of component lead size and printed wire board holes will ensure good solder joint design promoting uniform high reliability connections.

#8

During our visit to Honeywell, Inc. on December 15, 1982, we toured the RAAM production line and had a first-hand opportunity to see the wave soldering machine being operated to the issued process control chart.

This process has been developed by Messers. Katavala and Babatz (copy attached). The wave soldering machine has been customized to suit the various types of printed circuit boards being processed. The addition of the adjustable metal plate over the pre-heater section creating the top heater effect is a worthwhile addition.

Mr. Bob Babatz is a well trained wave soldering machine technician. It is imperative that a man of his training, expertise and dedication be kept on the machine to continue producing high quality products.

#9

Present Honeywell FASCAM deviation/quality assurance provisions will be changed from line drawings to actual color print photography. This should aid in determining acceptable solder connections. Every effort must be made to have acceptance criteria satisfy the specification requirements.

Section #11 explains progress in workmanship manuals, color photography, color prints, etc. for both Honeywell and ARRADCOM.

#10

This area can be addressed by Dwayne Dietrich, consultant to ARRADCOM. Until a plan mutually acceptable to Honeywell and ARRADCOM is selected and proven out, the existing contractual inspection specifications should be used.

PRODUCTION PROCESS
DETAIL
CONTINUATION SHEET

MAP #1

OPERATOR FOOT WEAR ☐ SAFETY GLASSES ☐ SAFETY GLASSES ☐ SAFETY GLASSES

December 15, 1982

ISSUE	DEPT NO.	GRP	OPERATION TITLE	PART NO.	
D C4	4528	82	WAVE SOLDER (AUDIT TABLE)	9287138K TAB	220A
REASON FOR ISSUE: ADDITIONAL INFORMATION				PART NAME: PW BOARD ASSEMBLY	SHEET 5 OF 5

WEEK ENDING ____________

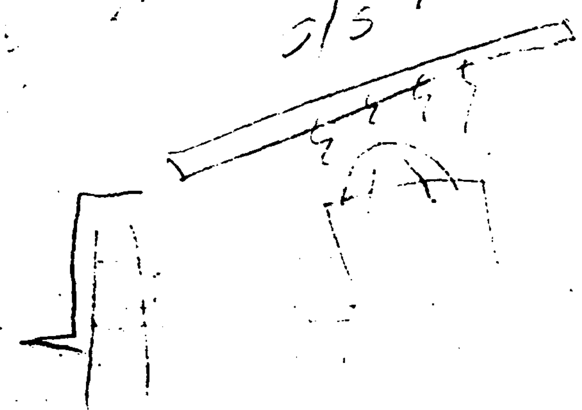
AUDIT WAVE SOLDERING MACHINE

9287138B TAB BOARD ASSEMBLY

CHECKS PRIOR TO OPERATION	FREQUENCY CHECK	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1. Solder level flush with level indicator	Start-up Pump off	12.15.82					
2. Set solder temperature @ 260°C ± 5°C 9287138B-T12	Start-up Pump on						
3. Oil level to overflow pipe.	Start-up Pump on						
4. Flux level	1 Gallon						
5. Record specific gravity or flux (.860 ± .005)	~~Change~~ ADJUST every (2) hours						
6. Thinner must be Alpha 425	A/R						
7. Flux must be MIL-F-14256 (Alpha 620-25)	A/R						
8. Preheater to ~~75~~ 85°C to ~~120~~ 101°C at top of PCB. (NOM. 93°C) 9287138B-T12	Start-up	— 185°F TO 212°F					
9. Conveyor speed (length) 2 min. ± 5 seconds	Start-up						
10. SOLDER ANALYSIS USE DETERMINATION	MONTHLY						
11 CONVEYOR LEVELNESS HORIZON LEV-CHECK	START-UP						

BOB

TRAINED MACHINE OPERATOR



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* (12) SOLDERING DEPTH > ½ BOARD THICKNESS — START UP

CONVEYOR LENGTH 112½" — 56¼ — 125 per — 1"/SEC — 5' PER MIN.

PART NUMBER	OPERATION NO.	NEXT ASSEMBLY (OPTIONAL)
	220A	

#11

During our meetings with Honeywell, it became apparent that inspection of soldered connections was subjective and also influenced by attitude and interpretation of the person doing the inspection. Most of the inspection criteria and subsequent quality deviations were line drawings which can add to the confusion since the accept/reject criteria is not clearly delineated. A decision was made to prepare actual samples of the inspection criteria and then each sample was photographed. We now have a complete workmanship manual on 35mm color slides and also a complete set of 2" x 3" color prints. Both Honeywell and ARRADCOM have a set in their possession. Work is in process to generate a Honeywell Workmanship Manual (under the supervision of Dave Tessmer) for FASCAM products. This manual and the 35mm color slides will be used in their training efforts and on the production floor to aid in the establishment of inspection criteria.

ARRADCOM is now considering making their own Workmanship Manual which will be used by the ARRADCOM field quality engineers in their interface with contractors working on FASCAM products.

#12

During the course of this task, we conducted two Soldering Technology Seminars at the ARRADCOM facilities in Dover, NJ. Working with Messers. Fitzsimmons, Miller and Schubert, we had two well attended presentations.

The attendees were a good cross-section of management, engineering and operations personnel working at ARRADCOM. The

first presentation was a Technical Soldering Technology lecture; the second presentation combined both lecture and hands-on soldering and thermal profiling work.

The critique sheets indicated that the seminars were very well received.

This type of training should be continued to ensure that the ARRADCOM field quality engineers and representatives are conversant with latest techniques, tools, and processes, and have a good background in soldering and soldering connection analysis.

#13

I had a scheduled visit to Aerojet, Downey, CA with Messers. Fitzsimmons and Schubert. We had a tour of the areas that were being used for FASCAM products. At the summary meeting (end of day), it was decided that I should spend another day analyzing and working at improving the wave soldering process. Working with John Murphy and Joe Berry, we developed a wave soldering adapter fixture for both AP and AT PWBs. The fixture has been designed and delivered to Aerojet.

On the second day, I worked with Joe Berry, helping set up the wave soldering machine starting with the foam fluxer, and proceeding through the pre-heater, solder wave and conveyor.

I have completed the actual in-plant work at Aerojet but remain on call if either John Murphy or Joe Berry need assistance by telephone.

CONCLUSIONS AND RECOMMENDATIONS

Based upon observations of the manufacturing processes at Honeywell, Inc., New Brighton, MN and Aerojet Corp., Downey, CA, the writer feels that certain major activities must be performed to ensure minimum risk and maximum reliability of the finished product.

The recommendations contained in this report will promote similarity in FASCAM products. ADAM and RAAM are both delivered to target in basically the same manner; both are expected to face the same stress conditions in storage and in use. Therefore, there should be a single, unified standard of workmanship for FASCAM products.

END

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